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COST-BASED VALUE MODELS OF AIR FORCE EXPERIENCE

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This research and development effort produced three models for potential use by Air Staff manpower and personnel planners in evaluating the cost and benefits of alternative enlisted and officer experience mixes. The models specify the costs of replacing key, trained personnel and valuing the future worth of services expected to be obtained from retaining such individuals in the Air Force. The first model, full investment cost, is a cost-based model reflecting expenditures necessary to replace personnel using historically determined career progression patterns and cost data. The other two models, stochastic rewards valuation and expected net present value, are value models reflecting the future expected worth of individuals to the Air Force. The methodology used in developing each of the models is presented, along with their application to the jet engine mechanic and air traffic controller occupational specialties. Results show the models to be useful in analyzing compensation and force management policy issues.

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SUMMARY

With increased pressures on the Air Force resulting from both reduced manpower and personnel budgets and decreasing manpower authorizations, the Air Force must make more effective use of the monetary resources at its command in order to maintain a highly trained personnel force. Being able to place a monetary value on experience in Air Force jobs and determine the cost of replacing key, skilled personnel is vitally necessary as the Air Force argues for an optimal experience mix in the force. This study derives a set of models for determining the cost and value to the Air Force of personnel with varying levels of experience in specific Air Force specialties (AFSs).

This investigation draws upon human resource accounting and human capital theory to build three different models for cost and value determination. The three models are: (a) full investment cost, (b) stochastic rewards valuation, and (c) expected net present value. The first of these models is a cost-based model which is backward-looking and determines the cost of replacing that individual. The remaining models are value models which are primarily forward-looking and determine the value of keeping an individual in a specific job in the Air Force.

Personnel and cost data on jet engine mechanics (AFS 426X2) and air traffic controllers (AFS 272X0) were used to develop each of the three models. The methodology involved identifying appropriate costs to include such factors as acquisition, development of personnel, and separation. The cost model results are presented for both AFSs and take into account the *force progression* patterns for each of the two specialties. Value model results are also presented for the two AFSs, based upon the same career progression patterns employed in the cost models but using estimates of the current and future value of services from individuals in the two AFSs based on wages paid to civilians in similar occupations. The results show that both the cost and value models provide insight into force management decisions through quantifying the relationships between key economic and force management policy variables. Applications of such models are suggested in pay, bonus, and retention policy decisions.

PREFACE

The work documented in this technical report is an integral part of the Manpower and Personnel Division's research program to understand the relationship between economic factors and accession and retention of a qualified enlisted and officer force. The research accomplished is in response to Request for Personnel Research 85-02, Quantifying Experience in the Cost of Human Capital, from HQ AF/DPXA and was conducted by RRC, Inc. of Bryan, Texas.

The authors wish to thank Lt Col Jim Hoskins of HQ AF/DPXA for his guidance in this effort as the Air Staff research requirements manager; Lt John McGarrity of AFHRL for his insights into application of cost and value model theory and review of this document; and Dr Eric Flamholtz and Mr Russ Coff of Management Systems, Los Angeles CA, subcontractor to RRC, Inc., for their experience and guidance in applying human resource accounting models. The corporate authors would also like to express appreciation to Ms Rebecca Wortman, research assistant; Ms Barbara Randall, computer programmer; and Mrs Kathy Berry and Mrs Carol Pulliam for their tireless efforts in producing quality draft and final manuscripts.

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I. INTRODUCTION

The Air Force is frequently required to address the impact of various compensation and personnel policies on the composition mix of the enlisted and officer forces. Budgetary and pay pressures force cost comparisons between force structures composed of different levels of experience, job skill, grade level, etc. Currently the Air Force has limited knowledge about how to place value on alternative force structures. The objective of the present effort is to assess the applicability of human resource accounting (HRA) and human capital methodologies for valuing Air Force experience. It will be necessary to relate various existing and new HRA approaches to the specific contents of the Air Force jobs, experience levels, and training, incorporating the most appropriate of these approaches into a model which values experience.

Section II presents two methodologies developed and tested in the HRA literature which are applicable to the valuation of Air Force experience. The strengths and weaknesses of both methodologies are discussed, as well as the data required for testing the approaches within the context of the Air Force personnel structure. Section III presents a test of the feasibility of applying the two models to the valuation of Air Force experience. Section IV presents conclusions and recommendations for valuing Air Force experience with the present HRA methodologies.

II. MODELS FOR VALUING HUMAN RESOURCES

This section discusses two specific models to value Air Force experience. One model is cost based and the other is value based. The following discussion presents the reasons for the selection of these two particular models. Section III presents an application of these models to two specific Air Force specialties (AFSs).

Human Resource Cost Models

Human resource cost models consider the costs which must be incurred to acquire, develop, and maintain human resources. They differ in the cost elements included and in the weights assigned to these cost elements. Different models are appropriate for different personnel and management decisions and environments.

An investment cost model includes acquisition, development, and separation costs for each position (Flamholtz, 1985). The inclusion of separation costs in the analysis may be particularly important for the Air Force. Unlike many private sector organizations, Air Force personnel often know ahead of time when they will leave active duty. This suggests that productivity losses due to pending separation could exist. Given the high turnover rate that the Air Force experiences for first-term enlisted personnel, the amount of lost productivity may be nontrivial.

The cost-based model employed in the estimations in Section III focuses on positional as opposed to individual cost. The concept of positional investment cost refers to the sacrifice that would have to be incurred today to replace a person occupying a specified position with a substitute who is capable of rendering equivalent services in the given position. There are three basic elements of positional investment cost:

1. Acquisition costs refer to the resource expenditure necessary to acquire or access a new position-holder, including all of the direct and indirect costs of recruitment, selection, hiring and placement.

2. Development/learning costs refer to the resource expenditure necessary to train a person and bring him/her to the level of performance normally expected from an individual in a given position. Learning costs are the costs incurred on each intermediate job level until an individual achieves the level of productivity normally expected in the critical or desired position. This loss of productivity is due to the performance of tasks at less than a 100% proficiency level. These costs include both direct and indirect costs incurred in formal orientation and training as well as on-the-job training (OJT). OJT costs are primarily reflected in the lost productivity of the trainee and the supervisor providing the training.

3. Separation costs are the costs incurred as a result of a position-holder leaving an organization. They include three basic elements: (a) direct separation costs, (b) differential pre-separation costs, and (c) vacant position costs. Direct separation costs include severance pay and the cost of any formal administrative procedures. Differential pre-separation performance costs refer to those costs associated with lost productivity prior to the separation of an individual from an organization, as there is a tendency for performance to decrease prior to anticipated separation. Vacant position costs are indirect costs resulting from less effective performance in positions which are impacted by the vacant position.

Investment Cost Models

An investment cost model can be applied using either a marginal or a full costing approach. Both approaches require the measurement of acquisition, development, and separation costs in each service state (job level). The marginal cost model measures the cash outlays necessary to hire and train one individual for the desired position, ignoring the possibility of attrition and the separation costs associated with attrition. The Air Force must hire more than one individual in order to obtain experienced personnel, as attrition is an integral factor in the personnel system. However, the marginal approach does provide most of the initial steps in the calculation of the full costing approach. In an internal labor market, marginal cost may be defined as:

1. the cost to recruit one person at the entry level, plus

2. the cost to select one person at the entry level, plus

3. the cost to develop one person at each intermediate level, plus

4. the separation cost for one person at the critical level.

In brief, this is the cost of replacing an individual in a given position or target level with a person who is assumed to remain in the organization throughout the developmental period. The marginal investment cost model assumes that one person must be acquired at the entry level and trained to ultimately function in the critical position.

However, as indicated above, the Air Force must recruit and select several individuals for each person who actually reaches a target position for replacement. This also means that more than one person may have to be developed at each intermediate level below the target position, as attrition is incurred at the intermediate levels. Part of the early attrition is the internal selection process which the Air Force performs in order to select individuals around whom the Air Force will build an inventory of needed skills and capabilities.

The full investment cost model (FICM) is a stochastic approach which recognizes that an organization must often acquire, develop, and separate many individuals in order to gain one person at the desired level. Because the Air Force allows entry only at the lowest level, the marginal investment cost model underestimates the actual costs incurred, by not accounting for attrition and its associated costs. In addition, the use of FICM allows for a sensitivity analysis of personnel policies directed toward reducing attrition in terms of cost savings. With this model, the Air Force could estimate the actual cost savings associated with various personnel programs, such as Selective Reenlistment Bonus, and emphasize those which are relatively more effective.

The full investment cost of a person may be defined as:

1. the cost to recruit one person multiplied by the number of new hires needed to gain one person at the critical level, plus

2. the cost to select one person multiplied by the number of new hires needed to gain one person at the critical level, plus

3. the cost to develop one person at each intermediate level multiplied by the number of people that must be developed on that level to gain one person at the critical level, plus

4. the cost to separate one person on each intermediate level multiplied by the number of people that separate on that level (attrition) before resulting in one person at the critical level.

The differential costs at each position or level are multiplied by the number of people impacted by that cost element to obtain a full investment cost.

Investment cost models have been used frequently to assess specific personnel problems in organizations (Flamholtz, 1985). There appear to be uses for these methods both as surrogates of value and as tools in a variety of phases of the manpower planning and control process. Practical application problems do exist, including subjectivity of required estimates for components of the models, particularly when indirect and opportunity costs are to be included. The full investment cost model can provide management with an idea of the potential impact of personnel policies.

Cost Information for FICM Calculation

The success from applying FICM relies upon the ability to assemble the cost elements associated with acquisition, development, and separation of personnel as they enter and leave the Air Force. These cost elements are comprised of several types of cost, some of which are readily available while others may require approximation.

Direct costs are those which are easily measured and traceable to the task, whereas indirect costs are those which must be allocated to the service state. Emphasis may or may not be placed on indirect costs. Including only direct costs provides a more reliable measure; but what it gains in reliability, it may lack in validity. For example, the cost of OJT is not part of the training budget and must be estimated as an indirect cost. Similarly, direct separation costs include only the cost of the paperwork and the exit interview. In the case of separation costs, the bulk of the costs could be the indirect cost of lost productivity prior to separation. Although measurements of indirect costs are often less reliable, their exclusion in any analysis of the valuation of Air Force experience reduces the validity of the model. In the estimation performed in Section III, indirect costs were included whenever reliable data or analysis could provide the costs. Omissions of known indirect costs are noted in Section III for future research efforts where additional data are available for obtaining the cost estimates.

Outlay and opportunity costs are similar in many ways to direct and indirect costs. Outlay costs refer to those which are measurable as cash outlays at some point. Opportunity costs refer to the foregone value of opportunities that would be incurred by a given decision. When a position is vacant in the Air Force, even though everyone will work harder and the work may still get done, it may take longer or be accomplished with less reliability; therefore, it does represent a reduction in potential productivity. Although this cannot be measured directly, it should be acknowledged. Some opportunity costs, however, can be measured and included. For example, a supervisor who administers OJT could be freed for other tasks if he/she did not have a trainee. This can be estimated by examining the amount of time the supervisor spends with the trainee over and above normal supervision. If one assumes that high quality personnel require less OJT, then the effect of quality on the level of OJT costs may be important in determining a desirable quality level of new recruits.

Human Resource Value Models

Where cost models look at the historical investments in people and are thus estimates of the value of experience, they do not provide a complete picture. For example, an individual with 20 years of experience would be valuable from a cost standpoint due to training and experience. On the other hand, if we know that an individual has a high probability of retiring in the next few years, the expected realizable value associated with his/her experience may be quite low. In such a situation, the Air Force must look beyond investment cost estimates.

Stochastic Rewards Valuation Model

The Stochastic Rewards Valuation Model (SRVM) (Flamholtz, 1985) was selected for the valuation of Air Force experience for a number of reasons. First, it has behavioral foundations (e.g., variations in attrition which are engendered by personnel behavior and affect the values for SRVM) that can be expressed in monetary terms, and it is therefore useful for personnel management. Second, although it was developed initially for the valuation of individuals, it has since been modified and applied to the valuation of organizations, using average values. Third, this model has been subjected to more validation and reliability testing than has any other value-based model (Flamholtz, 1971; Flamholtz & Lundy, 1975; Flamholtz & Searfoss, 1985). Finally, its treatment of human resource mobility as a stochastic process is particularly appropriate in the Air Force's mobile and transitory labor pool.

The model is based on the notion that an individual is valuable to an organization only in relation to the roles that a person may potentially occupy. Thus, an individual's value is determined in relation to the future services which are expected to be rendered to an organization by that individual. SRVM views the movement of people among organizational roles over time as a stochastic process with service state rewards. This model regards the movement of people from one service state to another as a probabilistic process depending upon the service states previously occupied. The model defines service states as organizational roles and the state of exit as leaving the organization. Rewards represent the value of services rendered to the organization as people occupy organizational roles. The model was developed to determine individual and group human resource value.

Since future states are uncertain, the model provides a measure of the expected value of a person's services. Thus, the measurement of an individual's value to an organization involves the following four steps:

1. Estimating the time period during which the person is expected to render services to the organization.

2. Identifying the service states that the person may occupy.

3. Measuring the service state value, which is the value derived by the organization if the individual occupies the state for the specified time period.

4. Estimating the probability that a person will occupy each state (including exit) at specified future times, referred to as transition probabilities (Flamholtz, 1985).

SRVM has been operationalized in international accounting firms (Flamholtz & Lundy, 1975; Flamholtz & Searfoss, 1985) and used to value the human assets in an acquired securities brokerage firm for income tax purposes (Flamholtz, Geis, & Perle, 1986). Section III presents the methodology employed for estimating SRVM for the Air Force.

Service State Values

One requirement of SRVM is the determination of the economic value associated with an individual's occupying a given position for one period. This is referred to as the service state value. In a service organization, each person's direct contribution to revenue is the rate at which their services are billed. This computation, however, is considerably more complex in the Air Force.

The calculation of the value of a service state requires the estimation of a monetary value of the product of military personnel at points along the career path. In a perfectly competitive market for factors of production, a firm will hire labor until the value marginal product (VMP) of the last unit of labor hired equals the cost of the labor unit; e.g., wage (Becker, 1971). Military compensation for enlisted and officer personnel is set at a level which may be under, over, or equal to the wage at which the competitive market values their services (Saving, Stone, Looper, & Taylor, 1985). Periodically, military compensation is increased in an attempt to attain or maintain military and civilian pay comparability. For example, there were pay raises in October 1980 and October 1981 of 11.7% and 14.3%, respectively. However, these are across-the-board pay increases and may not be sufficient for high demand career fields such as jet engine mechanics or pilots.

The Air Force uses Selective Reenlistment Bonuses (SRBs) to increase the compensation level in those enlisted AFSs which experience chronic manning shortages. A similar program for officer AFSs does not presently exist. Career fields that exhibit a history of shortages reflect military compensation levels which are below the civilian VMP of the labor input. The Air Force competes with the private sector industries for experienced enlisted and officer personnel. Since the Air Force competes with the private sector for labor, the civilian labor market provides a consistent market evaluation of VMP in the Air Force. For the SRVM analysis, wages paid in the private sector will be used as a measure of the VMP of Air Force enlisted and officer personnel in the production of national defense and as the basis for estimating the value of service states.

Expected Net Present Value Model

In an effort to increase the usefulness of SRVM for policy and personnel decisions, the expected net present value model (ENPVM) was developed. The only difference between the calculation of SRVM and ENPVM is the inclusion in ENPVM of all future expected costs of maintaining skills, additional training, special pay, and compensation. Thus, each service state value represents the monetary value of the product produced minus any costs associated with maintaining the labor input to obtain the value. The same present value calculation is performed for ENPVM as for SRVM, which accounts for the probability of exit based on the transition matrix. ENPVM uses the cost aspects of FICM and the value perspective of SRVM to produce an expected present value of future service to be rendered during a given service tenure.

III. ESTIMATION OF FICM, SRVM, and ENPVM FOR AN AIR FORCE SPECIALTY

Section II presented a theoretical discussion of two models which can be used to estimate the value of Air Force experience for a selected enlisted career field As indicated in Section II, the more difficult task of applying these models to Air Force experience is the collection, estimation, and/or determination of a proxy for the cost elements and transition matrix necessary to perform the calculations. Two initial steps in the application of the models were: the selection of the Air Force specialty (AFS) to which the models would be applied, and definition of the service states. Following these two steps, data were collected and the models estimated. The procedures followed in producing applications of the two models and a discussion of the results are presented in the rest of this section.

Definition of Service States

The first step in the calculation of costs and values for individuals at different stages in their careers was the definition of positions or service states in the Air Force career ladder. As discussed in Section II, a service state is one of a set of positions that provide unique value to the force and which an individual can attain as that individual progresses through a career. Proficient individuals within a service state provide services approximately equal to each other in value to the Air Force. For example, each year of service could be a different service state and would comprise a sufficient set of service states if each individual in each year of service provided equally valuable services to the Air Force. In contrast, service states could be based upon grade, skill level, and type of tasks performed, as long as the formulation met the criterion of a unique value for each service state.

The basis for selecting the set of service states for the analysis also considered the operational applicability of the service states within the Air Force personnel management system. Rank and skill level were chosen as components of the service states because they represented experience and quality in the Air Force personnel structure, and both factors form an integral part of the manning requirements for all AFSs. The service states chosen for this analysis differentiated between high and low skill levels based on grade; i.e., low grade represents low skill. Air Force skill level 9 was viewed as a single state comprised of both grades E-8 and E-9. The service states were defined as:

Service state	Rank	Skill Level
1	E-2	3
2	E-3	3
3	E-4	5
4	E-5	5
5	E-6	7
6	E-7	7
7	E-8, E-9	9

For this analysis, the service states defined above served as the basis for the computation of costs and values.

The primary sources for data for the project were the Uniform Airman Records (UARs) in the Historical Airman Data (HAD) base (Saving et al., 1985) and the Occupational Measurement Center's (OMC) survey files for the maintenance of the Comprehensive Occupational Data Analysis Program (CODAP) system (Christal, 1974). OMC provided insights into the Air Force career fields which might be most appropriate for use in the analysis that would follow. The analysis was performed at the 5-digit AFS level of disaggregation to minimize the possibility of non-standard training programs and unusual career paths for enlisted personnel. The selection of career fields on which the models were to be tested was based on (a) the availability of direct cost data; (b) the opportunity to obtain estimates of indirect costs — in particular, reliable OMC survey data; (c) the inclusion of all seven service states within the AFS personnel structure; and (d) the size of the career field, to ensure the calculation of transition probabilities for all service states. Additional discussions with the staff of OMC during the selection of the AFSs ensured a selection which maximized the possibility of obtaining both direct and indirect training costs at all junctures along the career path, in addition to minimizing changes and the complexity of job structure for the analysis. AFS 426x2, Jet Engine Mechanic, and 272x0, Air Traffic Controller, were the 5-digit AFSs chosen for the analysis. AFSs 426x2 and 272x0 had experienced the least amount of change in job duties and responsibilities since the OMC surveys were administered (Occupational Survey Reports, 1987, 1982) and had a sufficiently large inventory of personnel within the AFS.

Data for personnel in AFS 426x2 will be used to present the transition matrix and cost data development methodology. The definition used for the service state includes over 90% of the personnel in the AFS. Table 1 presents a distribution of enlisted personnel by service state for AFS 426x2 developed from the June 1986 UAR file. The table reveals that the service state definitions account for approximately 92% of all individuals in the AFS. Due to cross-training, the remaining 6% possessed combinations of rank and skill level which were not included in the definition of the service states. In addition, approximately 65% of the enlisted personnel are in service states 2, 3, and 4, which are comprised of grades E-3, E-4, and E-5. Service states 1, 2, and 3 consist primarily of first-term enlisted personnel, with a few first-termers in service state 4. Table 1 also presents the Total Active Federal Military Service (TAFMS) average for each service state. Since Air Force enlisted personnel have a minimum service commitment of 4 years, the average TAFMS column shows the predominance of first-term enlisted personnel in the first three service states. Although length of service did not explicitly enter into the definition of the service states, Table 1 reflects the chronological consistency of the service states and average length of service.

General Data Requirements and Development

A transition matrix was developed based upon the seven service states previously defined; it consists of the probabilities that an individual in a given service state will progress to the next service state 1 year in the future. To calculate the transition matrix for jet engine mechanics, data from the AFHRL HAD base were employed. UAR files for June 1985 and June 1986 were analyzed to develop the probability of moving from service state to service state, as well as the probability of separating from the Air Force. The June 1985 to June 1986 period was selected because the cost information available for the model estimations was from FY86. It should be noted that the transition rates for June 1985 to June 1986 would provide different values than would a lower retention rate time period such as 1978 to 1979. Lower retention rates would increase the FICM values and decrease the SRVM values. The transition matrix for AFS 426x2 is presented in Table 2.

The transition matrix rev[illegible] relatively high activity in states 1, 2 and 3 and relative stability in the last four states. Table 2 should [illegible] understood as follows: From June 1985 to June 1986, for an individual in service state 3 (rank [illegible], skill level 5), the probability of remaining in that service state was 0.602, while the prob[illegible]bility of advancing to service state 4 (rank E-5, skill level 5) was

Table 1. Enlisted Personnel by Service States:

Jet Engine Mechanic[a]

Service State	Rank/Skill	Count[b]	Percent[c]	TAFMS[d]
1	E-2/3	745	7.98	11.01 (5.84)[e]
2	E-3/3	1735	18.60	18.9 (8.50)
3	E-4/5	2165	23.21	45.67 (13.76)
4	E-5/5	2143	22.97	99.15 (36.37)
5	E-6/7	970	10.40	176.59 (31.64)
6	E-7/7	640	6.86	214.56 (33.64)
7	E-8,E-9/9	230	2.47	269.82 (55.17)

[a]AFS 426x2.

[b]Data from AFHRL Historical Airman Data Base, June 1986 UAR.

[c]4.80% of the 426x2 personnel are skill level 1; 1.70% of the personnel are E-1's, skill level 3 (in transition).

[d]TAFMS in months; Data from OMC Survey.

[e]Standard Deviation.

Table 2. Service State Transition Matrix:

Jet Engine Mechanic[a]

Service State (Rank/Skill) During Year T		Service State (Rank/Skill) During Year T+1							
		1	2	3	4	5	6	7	
Service State	Rank/Skill	(E-2/3)	(E-3/3)	(E-4/5)	(E-5/5)	(E-6/7)	(E-7/7)	(E-8,E-9/9)	Exit
1	(E-2/3)	0.130[b]	0.812	0.000	0.000	0.000	0.000	0.000	0.058
2	(E-3/3)	0.000	0.377	0.482	0.000	0.000	0.000	0.000	0.141
3	(E-4/5)	0.000	0.000	0.602	0.175	0.000	0.000	0.000	0.224
4	(E-5/5)	0.000	0.000	0.000	0.839	0.119	0.000	0.000	0.042
5	(E-6/7)	0.000	0.000	0.000	0.000	0.798	0.156	0.000	0.046
6	(E-7/7)	0.000	0.000	0.000	0.000	0.000	0.814	0.069	0.117
7	(E-8,E-9/9)	0.000	0.000	0.000	0.000	0.000	0.000	0.845	0.155

[a]AFS 426x2; developed from UAR files in the AFHRL HAD Base.

[b]Transition probability.

0.175, and the probability of separating from active duty was at 0.224. As indicated by Table 1 and reinforced in Table 2, service states 3, 6, and 7 identified individuals at the primary reenlistment/separation decision points in their enlisted career ladders, resulting in a larger probability of separation. The transition matrix in Table 2 was used in the calculation of both FICM and SRVM.

Direct Cost Components: Recruitment, Basic Military Training, Formal Technical Training

The source for the actual dollar value costs for recruitment, basic military training (BMT), and formal technical training was the Air Training Command's FY86 Cost Factors Manual (1986). As described in Section II, FICM identifies all explicit and implicit costs necessary to develop the human capital of the individuals in each service state. The initial cost of employing an individual in the Air Force, $1,866, is the cost of recruitment, as is listed in Table 3. Other initial costs presented in Table 3 for all individuals entering BMT is the $374 average cost of travel from Lackland AFB to the first duty station and a $535 clothing issue cost. These cost elements account for the expenditures necessary to place an individual in BMT. The average total cost for basic military training listed in Table 3 accounts for all the fixed and variable costs of training an individual, as well as the premature attrition during BMT. The final calculation of FICM included all the costs required to replace an individual at each of the seven service states and therefore included the fixed costs of providing BMT.

The Air Force continues to invest in the human capital of its employees after the completion of BMT through formal technical training in different specialty areas. The information provided in the Air Training Command's FY86 Cost Factors Manual (1986) was also used to develop the costs presented in Table 4 of providing technical training for jet engine mechanics. The average costs were computed for each course. The formal technical training costs allocated to each service state were estimated as a weighted average based upon the proportion of individuals who had taken a course in each service state. The proportion of individuals in each service state that completed training courses was estimated from the OMC survey data for jet engine mechanics. Table 5 presents these proportions by service state. The costs of formal technical training for each service state was a reflection of the courses taken by the population of enlisted personnel in each service state.

Indirect Costs: On-the-Job Training and Separation Costs

OJT was estimated primarily for individuals in service states 1 and 2; i.e., those individuals with the rank of either E-2 or E-3 and with a skill level of 3. To estimate the level of OJT which individuals received while in these two service states, OMC survey data were analyzed to provide an estimate of the functional relationship between time in service and proficiency. Due to the approach taken, no measurable dollar value for lost productivity due to OJT was determined for service states 5 and beyond.

A variable called average task difficulty per unit of time spent (ATDPUTS) was used as a surrogate for proficiency. ATDPUTS is based on the time spent learning to perform a particular task and the difficulty of the task. Table 6 presents the average percentage of time spent performing tasks within 16 defined duties for jet engine mechanics in each service state. Each duty is comprised of numerous tasks which occupy from zero to potentially 100% of an individual's work time. ATDPUTS is calculated by multiplying the percentage of time spent performing a given task by the difficulty of the task. The value assigned to the difficulty of performing each task ranges from 1 to 9 and was determined from an OMC survey of jet engine mechanic supervisors. Figure 1 presents the curve resulting from the estimation of the functional relationship between TAFMS and ATDPUTS for service states 1 and 2. The functional form used in the estimation of the relationship was

$$\text{ATDPUTS} = a + b_1\text{TAFMS} + b_2(1/\text{TAFMS}).$$

Table 3. FY86 BMT Acquisition Costs[a]

Enlisted Elements	Average Cost
Cost per Graduate	$ 3,640
Cost per Recruit	1,866
Travel: Lackland to Center/ Base	374
Initial Clothing Issue	535
Total Enlisted Acquisition Cost	$ 6,415

[a]FY86 Cost Factors May 1986, Director of Cost: DCS, Comptroller, HQ ATC, Randolph AFB, Texas, p. 31.

Table 4. Course Cost for Jet Engine Mechanic[a]

Course	Description	Average Cost
1	Jet Engine Mechanic	$9,135
2	Jet Engine Technician	3,149
3	Jet Engine Technician, GRCP-85 SRS I/O Maintenance	3,795
4	001 Jet Engine Accident Investigation	3,673
5	006 Jet Engine Technician (H-1F/H6-3)	5,089

[a]FY86 Cost Factors May 1987, Director of Cost, DCS, Comptroller, HQ ATC, Randolph AFB, Texas.

Table 5. Proportion Completed Technical Training

Courses by Service State: Jet Engine Mechanic

	Service State (Rank/Skill)						
	1	2	3	4	5	6	7
Course[a]	(E-2/3)	(E-3/3)	(E-4/5)	(E-5/5)	(E-6/7)	(E-7/7)	(E-8,E-9/9)
1	0.905	0.939	0.940	0.915	0.860	0.852	0.866
2	0.014	0.034	0.064	0.609	0.766	0.738	0.671
3	0.007	0.007	0.057	0.162	0.219	0.242	0.280
4	0.000	0.000	0.002	0.011	0.051	0.121	0.256
5	0.000	0.007	0.011	0.074	0.125	0.128	0.073

[a] Course	Description
1	Jet Engine Mechanic
2	Jet Engine Technician
3	Jet Engine Technician, GRCP-85 SRS I/O Maintenance
4	001 Jet Engine Accident Investigation
5	006 Jet Engine Technician (H-1F/H6-3)

Table 6. Percentage of Time Spent Performing Duties

by Service State: Jet Engine Mechanic

	Service State (Rank/Skill)						
	1	2	3	4	5	6	7
Duty[a]	(E-2/3)	(E-3/3)	(E-4/5)	(E-5/5)	(E-6/7)	(E-7/7)	(E-8,E-9/9)
A	1.537	2.326	4.341	5.135	10.606	4.905	24.300
B	2.069	2.058	5.432	8.147	14.014	17.840	25.377
C	0.314	0.691	1.168	3.076	8.119	13.356	30.152
D	0.340	1.053	3.133	6.688	7.858	8.134	5.229
E	8.451	8.188	11.406	13.012	13.558	12.069	5.051
F	3.515	4.362	4.172	4.615	6.582	7.303	6.575
G	8.689	8.570	10.298	9.143	6.324	4.075	1.160
H	21.587	21.404	12.472	9.538	6.570	3.933	0.312
I	0.532	1.765	1.231	0.373	0.401	0.175	0.000
J	1.207	2.134	2.469	2.421	1.456	1.910	0.114
K	0.853	0.542	0.808	0.365	0.264	0.174	0.011
L	47.153	44.129	39.507	33.971	21.844	14.463	1.581
M	3.113	1.982	2.602	3.008	1.983	1.549	0.041
N	0.167	0.284	0.240	0.182	0.135	0.030	0.000
O	0.197	0.120	0.299	0.085	0.040	0.033	0.023
P	0.254	0.364	0.386	0.200	0.205	0.008	0.044

[a] Duty	Description
A	Organizing and planning
B	Directing and implementing
C	Inspecting and evaluating
D	Training
E	Preparing and maintaining forms, records and reports
F	Performing quality control functions
G	Performing flightline engine maintenance functions
H	Performing in-shop engine maintenance functions
I	Performing balance shop functions
J	Performing test cell functions
K	Repairing and maintaining small gas turbine (SGT) engines
L	Performing general engine maintenance functions (general propeller-related tasks are listed in Duty P)
M	Performing cross-utilization training (cut) duties
N	Performing flightline propeller maintenance functions
O	Performing in-shop propeller maintenance functions
P	Performing general propeller maintenance functions

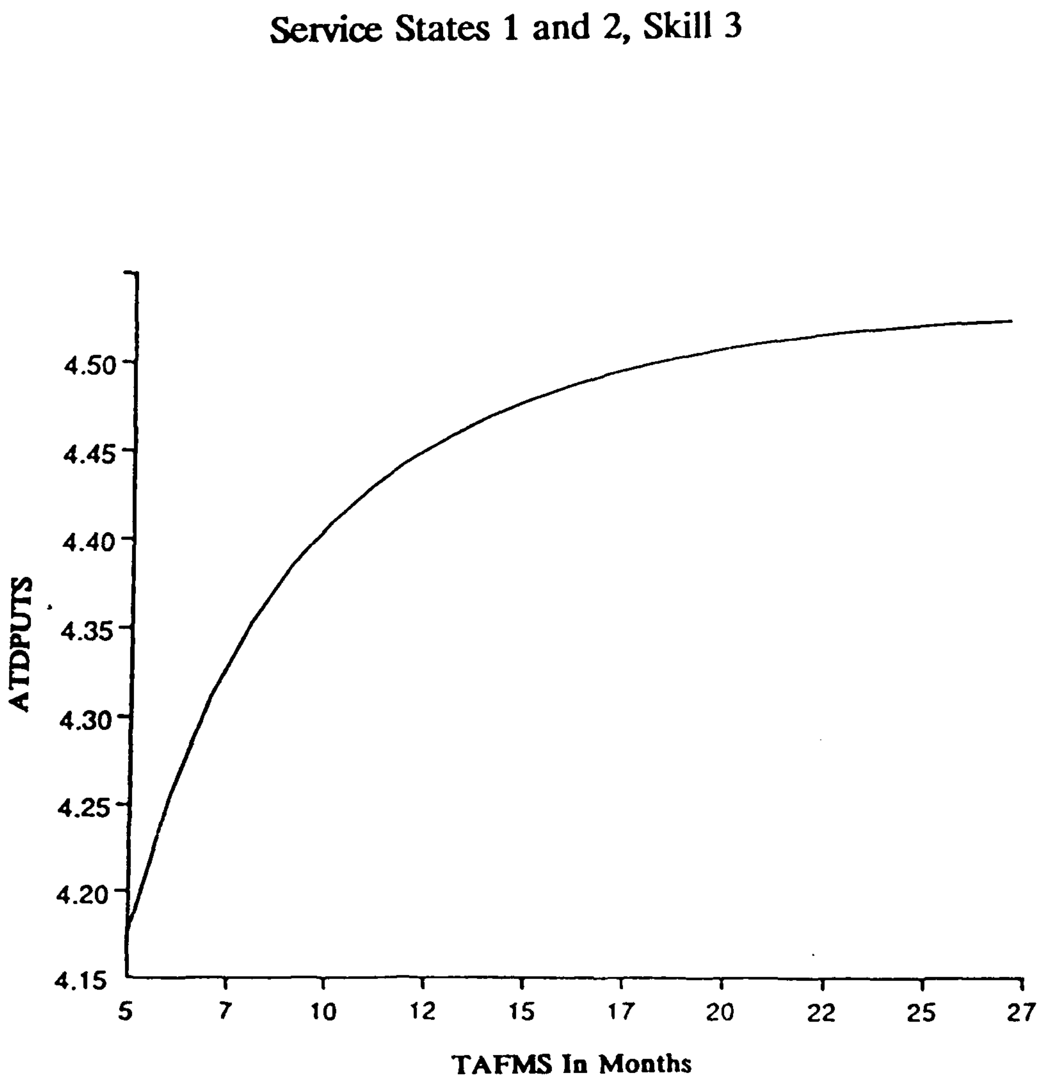

Figure 1. Estimation of OJT Lost Productivity Cost (OMC survey data for AFS 426x2)

The estimated relationship presented in Figure 1 represents a learning curve for the airman. If a dollar value is determined per unit of ATDPUTS, then the estimated relationship can be used to represent the productive value of the individual at any point along the learning curve. Table 7 presents the average ATDPUTS, military compensation, and dollars per unit of ATDPUTS by service state. As an individual progresses to the higher service states, military compensation increases for each additional unit of task difficulty.

The difference between the productive value and the compensation level of the individual at any point on the learning curve represents the value of the lost productivity from performing duties at less than 100% proficiency. The dollar value for a unit of ATDPUTS presented in Table 7 was multiplied times the functional relationship presented in Figure 1. The resulting monetized relationship was compared to the estimated function between TAFMS and military compensation. The area between the two curves represents the lost productivity which the Air Force incurs during OJT. The implicit assumption is that the military compensation paid to the individual represents that individual's dollar value to the military. If the two curves exactly matched each other, then the Air Force would be receiving an equal dollar value of output for each dollar of compensation paid; that is, the VMP would be equal to the wage.

Figure 2 presents the monetized version of the learning curve from Figure 1 and the curve representing the relationship between military compensation and length of service for service states 1 and 2. The difference between the slopes of the two curves becomes significantly smaller after approximately 12 months of service. The area between the two curves represents the cost of the lost productivity during OJT. As an individual with skill level 3 increases in proficiency, the person moves closer to full proficiency. Until that point is reached, the lost productivity of not performing at 100% is recognized as the investment made by the Air Force in OJT. The area between the two curves amounts to a $2,275 investment in OJT while individuals are at skill level 3.

Supervisor Lost Productivity Due to OJT. Time and effort spent on OJT may also be construed as lost productivity for the supervisor. The methodology employed to calculate the supervisor's component of lost productivity due to OJT is similar to the method described in Flemming, Cowardin, Reynolds, & Nielson, (1986). Some of the tasks which compose the training duty in Table 6 are directly associated with OJT. Table 8 presents a conservative estimate of the amount of supervisor time directly attributable to training airmen on the job. The cost of supervisor time was allocated among those individuals with skill level 3. Multiplying the supervisor cost times the number of supervisors and dividing that cost by the number of individuals receiving training yielded the trainer component of the lost productivity due to OJT. The trainer component of OJT per trainee was $2,308 for AFS 426x2. Combining trainee and trainer cost gave a total lost productivity cost due to OJT in skill level 3 of $4,583.

Estimation of Separation Costs. Airmen may exhibit a tendency to decrease their productivity as they approach a date of separation. An estimate of this lost productivity due to separation was included in the estimation of FICM values. Airmen surveyed by OMC were asked whether or not they planned to reenlist at the end of their current term of service. Individuals in each service state were grouped into potential reenlistments and potential separations depending upon the response to the question. An equation was estimated for each group in each service state to determine the relationship between TAFMS and ATDPUTS. Using the same methodology for conversion to dollars employed in the calculation of lost productivity due to OJT, Table 7, the two equations were monetized. (Figure 3 presents the monetized version of the two equations estimated for service state 3). The separation costs were assumed to be represented by the area between the two curves which represents the difference between the value of productivity for the two groups. The estimated separation costs for service states 1, 2, and 3 were $386, $389 and $982, respectively. On the average, individuals planning to separate in service states 4 through 7 performed more difficult tasks than did those who planned to reenlist, thus producing a negative separation cost.

Table 7. Military Compensation Per Unit of ATDPUTS[a]

Service State	Rank/Skill	Number	Average ATDPUTS	Military[b] Compensation	Military Compensation Per Unit of ATDPUTS
1	E-2/3	133	4.383	$ 14,403.60	$ 3,286.12
2	E-3/3	128	4.506	16,225.02	3,600.62
3	E-4/5	532	4.595	18,668.72	4,063.25
4	E-5/5	261	4.722	21,701.14	4,595.83
5	E-6/7	318	4.962	25,412.79	5,121.76
6	E-7/7	130	5.177	28,254.06	5,457.94
7	E-8,E-9/9	48	5.663	31,588.77	5,578.39

[a]Average task difficulty per unit of time spent.

[b]Military compensation is comprised of basic pay, basic allowance for quarters (BAQ), basic allowance for subsistence (BAS), and the marginal tax advantage for BAQ and BAS.

Service States 1 and 2, Skill 3

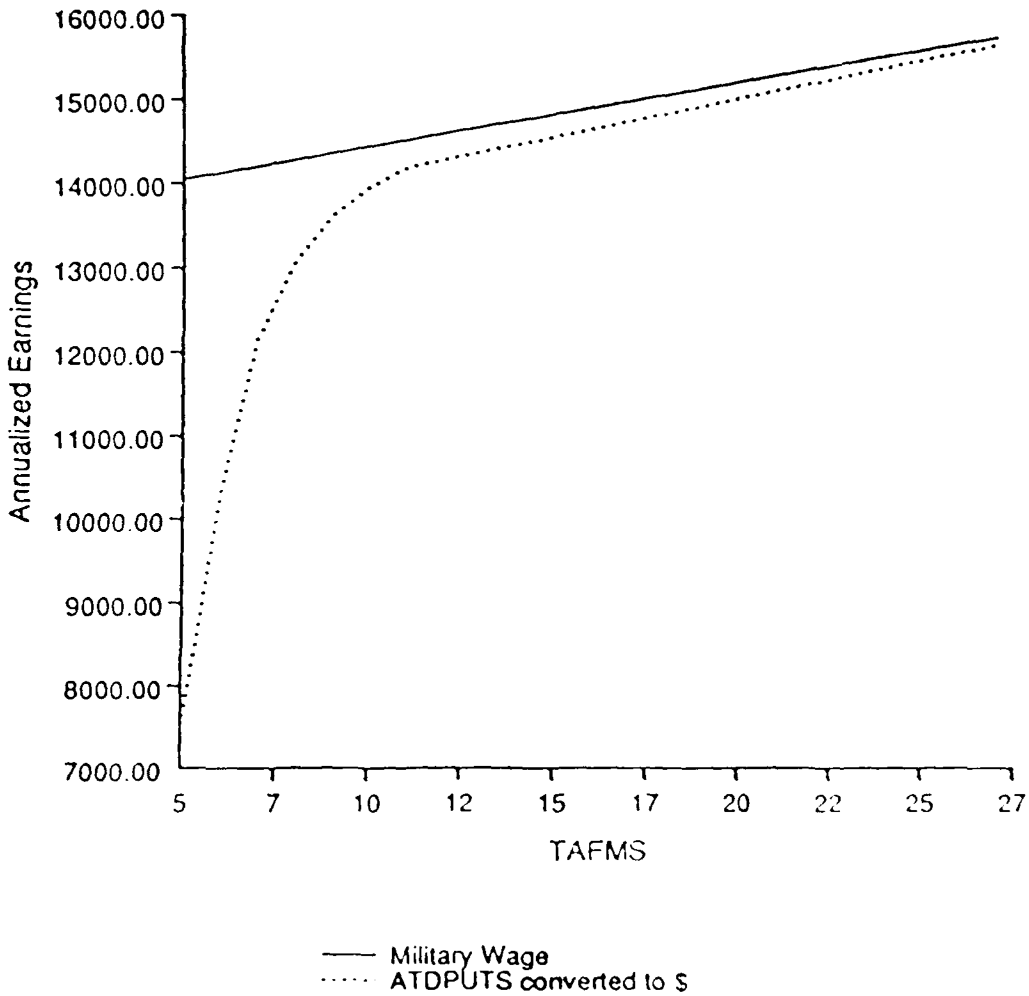

Figure 2. Estimated Learning Curve (OMC survey data for AFS 426x2, AFHRL HAD Base, and Current Population Survey data, 1986).

Table 8. Supervisor's Time: Jet Engine Mechanic[a]

Rank/Skill	Percentage of Supervisor's Time Conducting OJT	Supervisor's Military Compensation[b]	Supervisor Cost	Count	Total Annual Supervisor Cost
E-4/5	1.09	$17,194	$187	2165	$ 405,721
E-5/5	2.37	21,701	514	2143	1,102,174
E-6/7	2.98	25,413	757	970	734,588
E-7/7	3.17	28,254	896	640	573,217
E-8,E-9/9	2.34	31,598	740	230	170,060
			Total		$2,985,761
			Skill Level 3 Count		2,480
			Annual Cost/Trainee		$ 1,203.94
			Monthly Cost/Trainee		$ 100.33
			Number of OJT Months		x23
			Supervisor OJT Per Trainee		$ 2,307.59

[a]OMC Survey, Opened October 1980.

[b]Military compensation is comprised of basic pay, BAQ, BAS, and the marginal tax advantage.

Service State 3, Grade 4, Skill 5

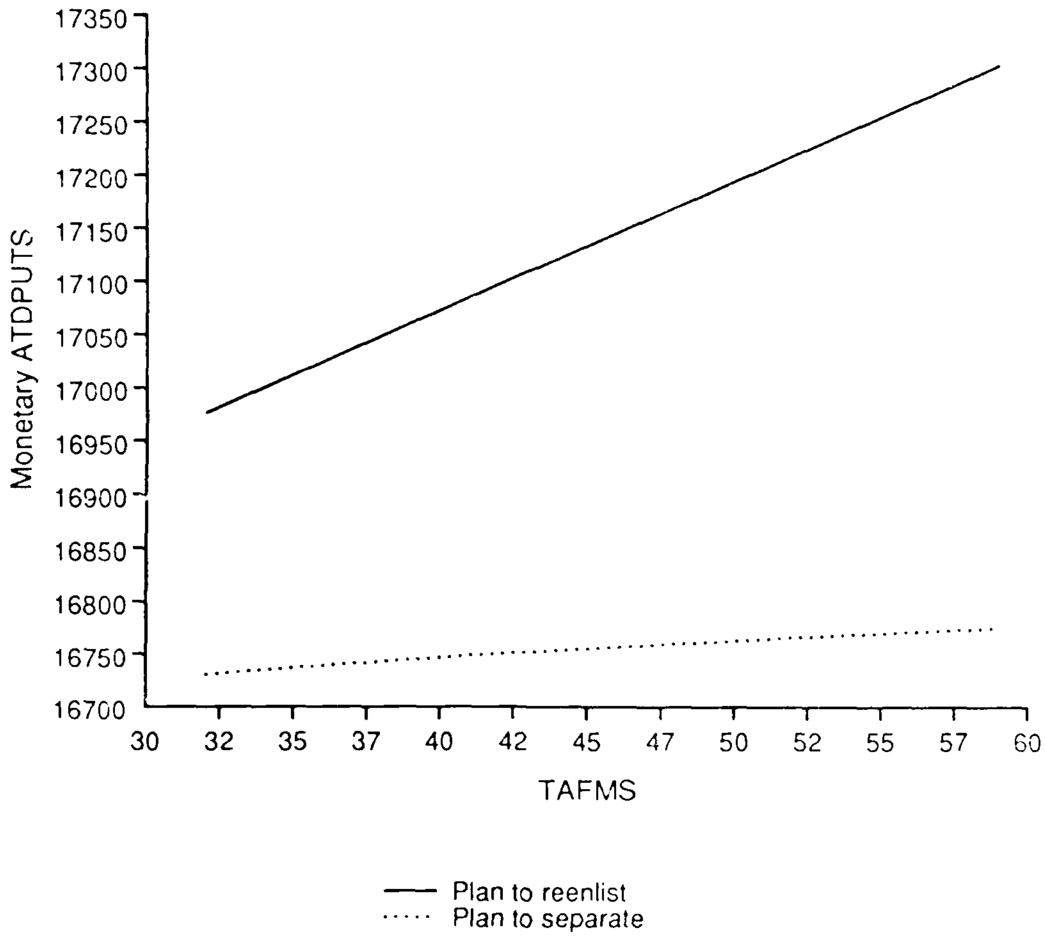

Figure 3. Estimated Separation Costs (OMC Survey Data, AFS 426x2), October 1980.

Study of additional AFSs and/or a more elaborate estimation approach which accounts for differences due to aptitude may assist in providing additional insights into the determination of separation costs for service states 4 through 7, as well as verifying the estimates for service states 1 through 3. Separation costs were added to the full investment cost at each service state at the rate individuals separated from that service state.

Full Investment Cost Calculation

The component costs of the FICM described above are presented together in Table 9 for jet engine mechanics. Column 1 presents the cost of acquiring an individual and providing basic military training. The amount presented in column 1 is the average cost and takes into account premature attrition at BMT. Because enlisted personnel enter the Air Force at the entry level, acquisition costs are the same for each service state (ignoring prior-service recruits which reduce acquisition costs).

Column 2 in Table 9 lists the formal technical training costs for each service state, based on those presented in Table 4. For skill level 3, service states 1 and 2 were assigned the average cost of the jet engine mechanic course. A weighted average technical training cost for the remaining service states was calculated using the course completion rates presented earlier in Table 5. An individual progressing through the service states incurs additional formal technical training costs from taking courses at the higher skill levels. The weighted average cost of formal training for an individual at service state 7 (E-8,E-9 and skill level 9) was $13,739, the sum of the technical training costs incurred in each service state.

The cost of the lost productivity due to OJT is listed for each service state in Column 3 of Table 9. The lost productivity cost is allocated across the individuals with a skill level 3 rating in service states 1 and 2. The proportion of lost productivity attributable to service state 1 was $2,834 and $1,749 for service state 2. For service states 3 through 7 the estimated lost productivity cost was zero. This indicates that additional lost productivity costs due to OJT were either minimal or not measurable beyond service states 1 and 2 under the present methodology for estimating lost productivity costs. Individuals continue to acquire new skills as they progress through their careers. However, since the cost of lost productivity due to OJT is based on the time required by the trainee and supervisor (not formal training costs), trainee and supervisor time are minimal beyond service state 2.

The final cost component of FICM consists of the separation costs listed for each service state in Column 4 of Table 9. As indicated earlier, separation costs were estimated only for the marginal separations from service state to service state. For example, reading from the replacement number column for service state 3, the marginal separation between service state 2 and 3 is 0.60, the difference between the replacement numbers of 1.82 and 1.22. The separation cost of $982 is multiplied by 0.60 to yield a total separation cost of $598, which is added to the FICM value for service state 3.

The sum of columns 1 through 3 yields an estimate of the marginal investment of training and promoting a single individual to each service state, ignoring the probability of separation at each intermediate level. These costs are presented in Column 5. However, FICM recognizes that to train and promote an airman to each service state requires an investment in more than one airman at each stage of the career ladder. The replacement number presented in Column 6 is the number of individuals who accessed into the Air Force and are necessary to replace a single individual in each of the seven service states. For example, 3.21 new recruits are required in order to attain one airman in service state 4; i.e., approximately 3.21 minus 1 airmen separate during the progression to service state 4. The replacement numbers are developed from the transition matrix presented in Table 2, which results from matrix multiplication for each year in the future.

Table 9. Full Investment Cost Calculation:

Jet Engine Mechanic

Service State	Rank/ Skill	(1) (Recruitment) BMT Acquistion Cost	(2) Technical Training	(3) OJT Cost	(4) Separation Cost	(5) Individual Invest[a] Cost	(6) Replmt[b] Number	(7) Full Invest[a] Cost
1	E-2/3	$6,415	$9,135	$2,834	$386	$18,384	1.06	$ 19,487
2	E-3/3	----[c]	----[d]	1,749	389	1,749	1.22	24,500
3	E-4/5	----	640	----[e]	982	640	1.82	37,695
4	E-5/5	----	2,432	----	----[f]	2,432	3.21	71,523
5	E-6/7	----	1,183	----	----	1,183	5.40	122,309
6	E-7/7	----	221	----	----	221	6.85	155,432
7	E-8,E-9/9	----	128	----	----	128	8.16	185,310

[a]Investment.

[b]Replacement.

[c]Acquisition and BMT costs apply only to service state 1.

[d]No formal technical training allocated to this service state.

[e]OJT lost productivity not allocated beyond service state 2.

[f]Separation costs were found negligible or negative for service states 4 through 7 and were disregarded.

Column 7 in Table 9 contains the full cost of training and promoting an individual to each service state. Included in that cost calculation are all the previously estimated investment costs which were incurred by the Air Force in developing the productive capabilities of its enlisted personnel to perform as jet engine mechanics, including the lost investment in individuals who separated prior to each service state. For example, to train and promote an individual to service state 3, which is the equivalent of a fully trained, first-term airman, the Air Force will invest $37,695 in the training of 1.82 new employees and will not receive the use of a fully productive individual for almost 4 years (see Table 1). The cost to the Air Force of training and promoting an airman to service state 5, which is the equivalent of a career airmen with over 14 years of military experience, is $122,309. Service state 5 requires 5.4 new recruits in order to obtain one airman at the desired service state. Appendix A provides a more detailed step-by-step explanation of the calculation of FICM values for individual service states.

Table 10 presents FICM estimates for air traffic controllers, AFS 272x0. The methodology and data sources used to develop the estimates for jet engine mechanics was also used to provide the FICM estimates for air traffic controllers. The only column which is the same for the two AFSs is column 1, BMT Acquisition Cost. Columns 2 through 7 are AFS-specific. Technical training costs for air traffic controllers tend to be higher for most service states in which training regularly occurs; e.g., service state 1. Total lost productivity costs due to OJT for the first two service states are comparable for the two AFSs: $4,583 for AFS 426x2 and $4,771 for AFS 272x0. Separation costs are different for each service state but fall within the same range. The replacement numbers are also comparable until service state 6 is reached. Thus, the key differences between the two AFSs are the cost of formal technical training and the replacement numbers in service states 6 and 7, both of which contribute to the difference in the FICM estimates for service states 1 through 7. Service state 4, rank E-5 and skill level 5, is the only service state in which jet engine mechanics exhibit a larger FICM value, due solely to a 25.39% higher replacement number for jet engine mechanics than for air traffic controllers (3.21 versus 2.56, respectively). Otherwise, air traffic controllers exhibit a higher FICM value, ranging from only a $6,954 difference at service state 1 to a $120,128 difference at service state 7.

Stochastic Rewards Valuation Calculation

FICM is a measure of the present cost of replacing enlisted personnel in each of the seven service states. The stochastic rewards valuation model presented in this section addresses the question of the value to be derived by the Air Force from employing individuals at each relevant service state over some selected future horizon.

Estimation of SRVM values for jet engine mechanics represents a monetary valuation of the future expected services to be provided by enlisted personnel from continued active duty. SRVM accounts for the probability of separation at all future career points by using the transition matrix developed for the estimation of FICM. In essence, the estimation of SRVM for some selected tenure of future service provides an estimate of the expected value of that future service based on the probabilities of occupying various service states. The estimation of SRVM also employed the same service state definition as used in the calculation of FICM.

The two main data elements required by the SRVM are the service state values and the transition probabilities. The value of each service state is based on the civilian wage of a jet engine mechanic as computed from data collected monthly by the Bureau of the Census (U.S. Department of Commerce, 1986). One-fourth of the individuals responding to the survey each month are asked to provide weekly earnings information. The respondents can be categorized by occupation using the Standard Occupational Codes provided on each individual record. The data used for the estimation of SRVM were 1986 data from individuals categorized as aircraft engine mechanics. The

Table 10. Full Investment Cost Calculation:

Air Traffic Controller

Service State	Rank/ Skill	(1) (Recruitment) BMT Acquistion Cost	(2) Technical Training	(3) OJT Cost	(4) Separation Cost	(5) Individual Invest[a] Cost	(6) Replmt[b] Number	(7) Full Invest[a] Cost
1	E-2/3	$6,415	$14,921	$3,375	$533	$24,711	1.07	$ 26,441
2	E-3/3	----[c]	306	1,396	518	1,702	1.17	30,823
3	E-4/5	----	33	----[d]	598	33	1.93	51,235
4	E-5/5	----	68	----	----[e]	68	2.56	68,245
5	E-6/7	----	2,822	----	----	2,822	4.71	130,752
6	E-7/7	----	2,950	----	----	2,950	7.72	219,147
7	E-8,E-9/9	----	2,052	----	----	2,052	10.66	305,438

[a]Investment.

[b]Replacement.

[c]Acquisition and BMT costs only apply to service state 1.

[d]OJT lost productivity not allocated beyond service state 2.

[e]Separation costs were found negligible or negative for service states 4 through 7 and were disregarded.

age-earnings function estimated for jet engine mechanics exhibits the following relationship between earnings and age:

$$\text{Earnings} = a + b_1\text{Age} + b_2(\text{Age}^2).$$

Figure 4 presents a comparison of the civilian and military age-earnings functions estimated for jet engine mechanics and indicates the points along the curves associated with each service state. It also demonstrates the similarity in the estimated relationships between military and civilian earnings and age for jet engine mechanics. The Air Force is compensating jet engine mechanics at a rate comparable to but lower than the private sector's valuation of labor's VMP. Figure 5 presents a similar comparison for air traffic controllers which shows that the civilian earnings potential is significantly above that of their military counterparts, with the maximum difference occurring at approximately 31 years of age or service state 5, rank E-6 with skill level 7. Service state 5 represents the beginning manager level in the Air Force personnel structure.

The probabilities of attaining future service states are a product of matrix multiplication of the transition probabilities presented in Section II. For a detailed discussion of the calculation of the SRVM estimates see Appendix B. Tables 11, 12, 13, and 14 present SRVM estimates under different assumptions concerning future horizons for jet engine mechanics and air traffic controllers. In Tables 11 and 12, the estimates represent the future value to the Air Force of an individual for a future tenure of 4 years. Tables 13 and 14 provide SRVM estimates for an expected tenure to voluntary retirement at 20 years of service, assuming a beginning length of service equal to the mean TAFMS exhibited for each service state in Table 1.

The average value of $44,850 in Table 11 for the first three service states reflects the high probability of separation at the first-term decision point encountered in service state 3. Once the first-term reenlistment decision has been made, the value of an airman's future services increases significantly. The value of $72,441 in service state 4 reflects the high probability of continuation for the next 10 to 15 years in an airman's career including reenlistment/separation to be made at the end of the second term. The value to the Air Force of continued tenure for service states 6 and 7 declines because of the short tenure of service before the 20-year retirement point and the high probability of retirement. A similar pattern is exhibited in Tables 12, 13, and 14 even though different expected tenures and two different AFSs are used for the SRVM estimates. In Tables 13 and 14, the calculation for service state 7 is not performed since these airmen exhibit a mean length of service beyond 20 years (See Table 1). The SRVM estimates for air traffic controllers are consistently higher than those for jet engine mechanics, due to the replacement numbers and the higher VMP estimate (Figure 5) for air traffic controllers.

Calculation of ENPVM Values

Tables 15 and 16 present calculations for ENPVM for jet engine mechanics and air traffic controllers, respectively, assuming an expected tenure of 4 more years and until retirement at YOS 20. Appendix B presents a detailed discussion of the calculation of ENPVM values. A jet engine mechanic at service state 3 has an ENPVM value of $8,524, column 4, which is the value of 16 additional years of service less all costs to maintain, train, promote, and compensate the mechanic. In essence, the Air Force will incur a net benefit of $8,524 from retaining the services of service state 3 personnel until voluntary retirement. Service state 4 exhibits the greatest net benefit from an expected tenure to retirement, column 4 in Tables 15 and 16. Air traffic controllers exhibit larger net benefits to the Air Force than do jet engine mechanics across service states, due to the larger service state values estimated for air traffic controllers (Figures 4 and 5).

Aircraft Engine Mechanics/AFS 462x2

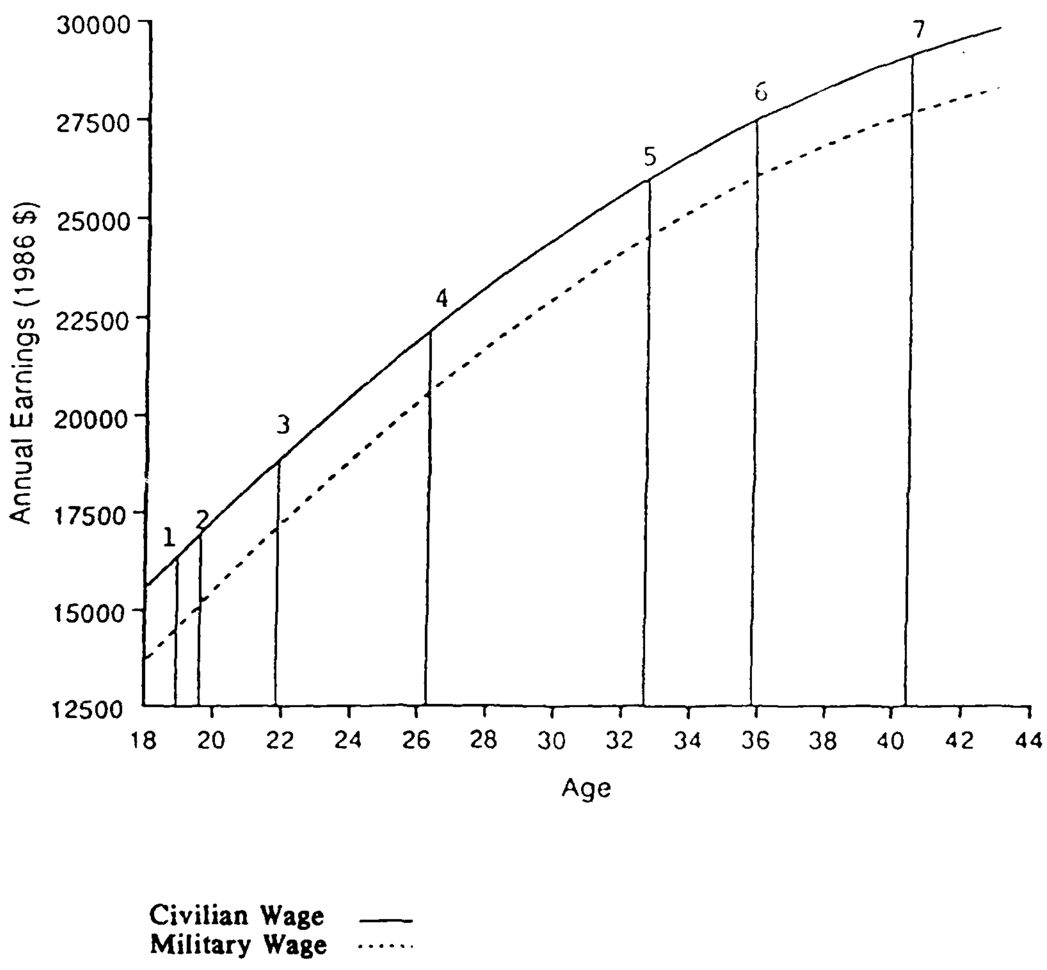

Figure 4. Civilian/Military Age Earnings Comparison Current Population Survey data (1986), OMC survey data, and AFHRL HAD Base.

Air Traffic Controllers/AFS 272x0

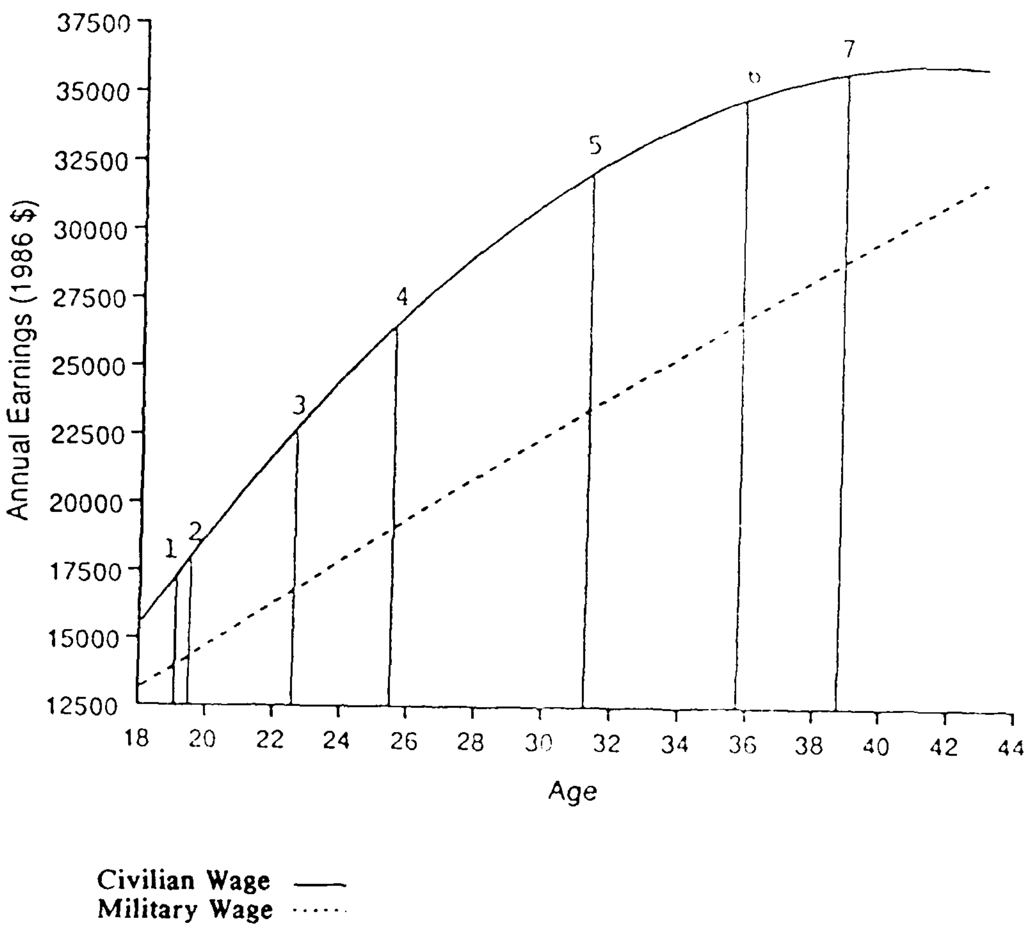

Figure 5. Civilian/Military Age Earnings Comparison (Current Population Survey data (1986), OMC survey data, and AFHRL HAD Base).

Table 11. SRVM Estimation for 4 Years of Future Service:

Jet Engine Mechanic

Service State	Rank/Skill	Value[a]	Present Value[b] of Future Rewards
1	E-2/3	$16,366	$47,132
2	E-3/3	16,952	43,499
3	E-4/5	18,839	43,918
4	E-5/5	22,143	72,441
5	E-6/7	25,991	80,173
6	E-7/7	27,476	71,434
7	E-8,E-9/9	29,139	68,391

[a]Civilian equivalent for service state.

[b]5.96% Discount Rate - Treasury Bill rate for 1986.

Table 12. SRVM Estimation for 4 Years of Future Service:

Air Traffic Controller

Service State	Rank/Skill	Value[a]	Present Value[b] of Future Rewards
1	E-2/3	$17,303	$ 57,164
2	E-3/3	17,991	58,236
3	E-4/5	22,684	52,418
4	E-5/5	26,475	77,069
5	E-6/7	32,104	99,590
6	E-7/7	34,802	91,670
7	E-8,E-9/9	35,767	89,576

[a]Civilian equivalent for service state.

[b]5.96% Discount Rate - Treasury Bill rate for 1986.

Table 13. SRVM Estimation for Military Service to Retirement:

Jet Engine Mechanic[a]

Service State	Rank/ Skill	Value[b]	Present Value[c] of Future Rewards
1	E-2/3	$16,366	$ 95,635
2	E-3/3	16,952	90,104
3	E-4/5	18,839	94,813
4	E-5/5	22,143	153,170
5	E-6/7	25,991	94,553
6	E-7/7	27,476	42,243
7	E-8,E-9/9	29,139	-----[d]

[a]Retirement is assumed to occur at 20-years of service.

[b]Civilian equivalent for service state.

[c]5.96% Discount Rate - Treasury Bill rate for 1986.

[d]This service state is on average past the 20-year retirement point, see Table 1.

Table 14. SRVM Estimation for Military Service to Retirement: Air Traffic Controller[a]

Service State	Rank/ Skill	Value[b]	Present Value[c] of Future Rewards
1	E-2/3	$ 17,303	$122,510
2	E-3/3	17,991	120,630
3	E-4/5	22,684	104,191
4	E-5/5	26,457	155,271
5	E-6/7	32,104	146,643
6	E-7/7	34,802	53,917
7	E-8,E-9/9	35,767	----[d]

[a]The value of a reenlistment for one additional four-year term of service versus replacement of the individual.

[b]Civilian equivalent for service state.

[c]5.96 Discount Rate - Treasury Bill rate for 1986.

[d]This service state is on average past the 20-year retirement point, see Table 1.

Table 15. Expected Net Present Value:

Jet Engine Mechanic

(1) Service State	(2) Rank/ Skill	(3) YOS[a]	(4) ENPVM (To Retirement)	(5) ENPVM (4 More Years)
1	E-2/3	19	6,768	2,591[b]
2	E-3/3	18	8,753	4,825
3	E-4/5	16	8,524	4,253
4	E-5/5	12	11,388	4,384
5	E-6/7	5	10,045	8,419
6	E-7/7	2	5,406	9,148
7	E-8,E-9/9	----[c]	-----[c]	8,860

[a]Years of service until retirement at YOS 20 based on mean TAFMS in Table 1.

[b]When the cost of BMT (military-specific training) is excluded from the costs in service state 1, the ENPV to 20 years becomes - $7,277, and the ENPV for 4 more years becomes $3,100.

[c]For service state 7, the mean TAFMS is greater than 20 years, See Table 1.

Table 16. Expected Net Present Value:

Air Traffic Controller

(1) Service State	(2) Rank/ Skill	(3) YOS[a]	(4) ENPV (To Retirement)	(5) ENPV (4 More Years)
1	E-2/3	19	30,376	11,123[b]
2	E-3/3	18	36,304	18,429
3	E-4/5	15	32,455	17,878
4	E-5/5	13	45,503	24,711
5	E-6/7	7	36,471	25,141
6	E-7/7	2	12,305	20,849
7	E-8,E-9/9	-----[c]	-----[c]	19,111

[a]Years of Service until retirement at YOS 20 based on mean TAFMS in Table 1.

[b]When the cost of BMT (military-specific training) is excluded from the costs in service state 1, the ENPV to 20 years becomes $31,064 and the ENPV for 4 more years becomes $11,811.

[c]For service state 7, the mean TAFMS is greater than 20 years, See Table 1.

Several factors affect the values for ENPVM which could be altered by personnel policies. For example, if an SRB were implemented for first-term personnel, the increase in the continuation rates at the first-term decision point would increase the ENPVM value at the same time that the value of the bonus would decrease the ENPVM value. The net effect would determine the overall value of the bonus. Employment of ENPVM in such an analysis requires a caveat: ENPVM is totally a forward-looking model and does not consider the savings in reduced recruiting, selecting, and training which occurs prior to a particular service state. For example, service state 3 exhibits a mean TAFMS of 3.81 years (see Table 1). BMT and formal technical training costs are incurred in service state 1 while OJT lost productivity costs are primarily incurred in service states 1 and 2. A reenlistment bonus for first-termers would affect the continuation rates for service states 3 and beyond while reducing training costs in service states 1 and 2. This is because fewer recruits are required to replace losses in service states 3 and beyond. Thus, when analyzing the effects of a proposed bonus program, the size of the net benefit may not be as important as a positive ENPVM estimate.

Comparison and Interpretation of FICM, SRVM, and ENPVM Values

Each model has been estimated for jet engine mechanics and air traffic controllers. Each can be useful in providing insights into the relative costs of various personnel policies, and each provides a different perspective for decision-making. As such, managers should carefully examine information provided by each of the models in making decisions, rather than focusing on only one mode of analysis.

For example, FICM suggests that a person's value to the Air Force increases dramatically as the individual advances through the service states because the Air Force continues to invest in people. FICM shows very significant jumps in the FICM values as airmen progress to service states 3, 4, and 5 (Tables 9 and 10), reflecting the reenlistment/separation options available to enlisted personnel at these junctures of the career ladder. FICM would lead one to conclude that service state 7 personnel are the most valuable to the Air Force. Therefore, it would appear that the Air Force would benefit from almost any effort to reduce turnover at this level. FICM reflects investments in training, selection, and other activities required to develop a service state 7 person. Thus, this conclusion is based on the training investments required to develop a person to attain this service state.

The present value estimates provided by SRVM present a different story. As Tables 11 through 14 demonstrate, the expected value of future services increases significantly through service state 4 and declines thereafter. This is true in spite of the fact that the value of each service state gradually increases. The reason for the decline in the value of SRVM for service states 6 and 7 is that, unlike the investment cost models, SRVM looks at expected future rewards. Thus, the impact of expected turnover is implicit in the calculation of the values for SRVM. Personnel in service state 7 are likely to retire given the average mean length of service presented in Table 1, approximately 22.5 years. The future services which can be realized by the Air Force are limited in service state 7 due to the impending retirement of the service state 7 personnel.

ENPVM is an attempt to combine the forward-looking aspect of SRVM with the cost consciousness of FICM to estimate a net benefit to the Air Force from an expected future tenure. Since the Air Force provides a significant amount of Air-Force-specific training, the civilian wage of the age-comparable civilian counterpart underestimates the value to the Air Force of these unskilled or semi-skilled workers in service state 1, producing the smallest value for ENPVM for a 4-year tenure (Tables 15 and 16). The ENPVM values increase by 86% and 66%, respectively, in Tables 15 and 16 when comparing the service state 1 and 2 values for a 4-year tenure. The private sector does not place great value on Air-Force-specific skills since these skills may not contribute much to the production of private sector goods and services. Of course, the ENPVM values for service state 1 under the assumption of a 4-year tenure may also indicate the need for a more extended tenure to retrieve the investment made by the Air Force in the training of airmen in these two career fields.

Perhaps the most important thing that FICM, SRVM, and ENPVM bring to the decision-making process is a different paradigm. When the Air Force considers people as organizational assets to be optimized, rather than expenses to be minimized, it implicitly adopts a more long-term perspective. This can be illustrated through the analysis of compensation decisions.

The Air Force tries to balance military and civilian compensation and benefits. The military may adopt a compensation strategy which is lagging, matching, or exceeding civilian compensation. The appropriate level often depends on the Air Force's strategy of pay comparability. The models proposed in this report allow the Air Force to measure the costs and benefits associated with each strategy. Sensitivity analysis can be performed to indicate the probable impact of a given compensation strategy on expected benefits and/or investment costs.

Since transition rates affect FICM, SRVM, and ENPVM estimates, increases in military compensation relative to civilian compensation should decrease attrition in most service states though the magnitude of the change would decline through service states 5, 6, and 7 (Saving, Stone, Looper, & Taylor, 1985). This, in turn, means that people are more likely to stay in the service long enough for the Air Force to realize a return on training; i.e., the net present value of personnel would increase. Thus, an increase in military compensation would lead to a decrease in the FICM values and an increase in the SRVM values due to increased retention rates. The investment costs may actually decrease if the higher wage brings in better recruits, reducing premature attrition and OJT. In this way, using FICM, SRVM, and ENPVM allows the Air Force personnel manager to weigh costs and benefits of a given compensation strategy, rather than merely examining the costs. This implies that the Air Force should adopt a long-term perspective when employing FICM, SRVM, and ENPVM as tools for considering personnel policy changes, rather than solely considering changes in budget costs due to the implementation of the wage increase.

IV. CONCLUSIONS AND RECOMMENDATIONS

Section III presented the results of applying FICM, SRVM, and ENPVM to two 5-digit AFSs. The application of these three models to AFSs 426x2 and 272x0 indicates several research avenues for consideration and obvious conclusions:

1. FICM, SRVM, and ENPVM provide information which is useful in determining and explaining the costs and implications of personnel policy.

2. FICM, SRVM, and ENPVM can be estimated for any career field or any level of aggregation by employing the same methodology as used in the application presented in Section III.

3. Some of the indirect costs estimated in Section III may be generalized to all AFSs, and additional study is necessary to identify indirect costs (e.g., separation costs).

4. OMC survey data should receive additional study to determine whether a different calculation of ATDPUTS can be performed which would provide better means for estimating supervisor and trainee OJT costs.

5. FICM, SRVM, and ENPVM can be applied to the officer corps employing the same methodology used in Section III, though a redefinition of service states is required to appropriately model the organization of the officer corps.

6. Alternative measures for the valuation of service states for SRVM and ENPVM estimates should be considered, such as productive capacity (Carpenter, Monaco, O'Mara & Teachout, 1989).

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APPENDIX A: FICM CALCULATION

Table 9 on page 22 presents the results of using the FICM methodology for the calculation of full investment cost estimates for each of seven service states. The following discussion will provide a step-by-step calculation of the FICM estimates for the first two service states in Table 9.

The estimate of the FICM value for service state 1 is equal to the replacement number for service state 1 in column 6, 1.06, multiplied times the individual investment cost in column 5, $18,384, which equals $19,487 in column 7. Although a 0.06 separation rate occurs during service state 1, the calculation assumes that these separations do not incur a separation cost since the individuals have not received their first assignment and are relatively unproductive. The separation costs indicated for service state 1 in column 4 apply to personnel who are in the process of progressing from service state 1 to 2 and do not become a part of the FICM calculation until service state 2.

The estimates of the FICM values for service states 2 through 7 become progressively complex. The FICM value for service state 2 is the sum of three products.

1. The replacement number for service state 2 in column 6, 1.22, multiplied by the individual investment cost of service state 1 in column 5, $18,384. This product provides the investment cost incurred for the 1.22 recruits in service state 1, (1.22)($18,384) equals $22,428.

2. The individual investment cost of service state 2 in column 5, $1,749, multiplied times the number of individuals who completed service state 1, which is the product of the replacement number for service state 2 in column 6, 1.22 and the reciprocal of the replacement number for service state 1 in column 6, (1/1.06) = 0.943. The reciprocal of the replacement number for service state 1 equals the probability of completing service state 1, (1/1.06) = 0.943. The product of the reciprocal and the replacement number provides the number of individuals who completed service state 1 of the 1.22 recruits who began the process, (0.943)(1.22) = 1.15. This product provides the investment cost incurred in service state 2 for those 1.15 individuals who progressed past service state 1 into service state 2, (1.15)($1,749) equals $2,011.

3. The separation costs incurred for those individuals who separated between service states 1 and 2 in column 4, $389, multiplied by the number of individuals who separated between service states 1 and 2. The number who separated is equal to the number of individuals who completed service state 1, 1.15 (computed in (2)) minus 1, which is the number to complete service state 2, producing a 0.15 separation rate between service states 1 and 2. This product provides the total separation costs incurred for separations between service states 1 and 2, (0.15)($389) equals $58.

Thus, the FICM value for service state 2 is ($22,428+$2,011+$58) which equals $24,497. The difference of $3 between the step-by-step calculation and the estimate provided in Table 9 is due to the rounding which occurs during the step-by-step calculation, versus the calculation performed by a computer software program in one complex step.

The estimate of the FICM value for service state 3 continues to become more complex as attrition and training increase for one additional service state through which the 1.82 recruits must progress. The estimates of the FICM values for service states 4 through 7 follow the same methodology, with individuals progressing through more service states to reach the designated service state and incurring additional separation costs for separations between service states 2 and 3 and between service states 3 and 4.

APPENDIX B: SRVM AND ENPVM CALCULATIONS

Table 11 on page 28 presents the results of using the SRVM methodology for the calculation of value estimates for each of 7 service states for an expected tenure of 4 years. The following discussion provides an example of a step-by-step calculation of the SRVM estimates for service state 1.

Table 11 provides two sets of information for each service state. First is the value to be derived by the Air Force from an individual occupying a service state, such as $16,366 for service state 1. Second is the estimate of the SRVM value for 4 additional years of service given the service state as the starting point, such as $43,499 worth of value from an individual in service state 2 for 4 more years of service. Table 2 presents the transition probabilities associated with progressing from one service state to another from any time period t to t+1.

Table B-1 provides the probabilities of obtaining future service states over four additional years of service that were used as the transition rates in Table 11's calculations. For example, the probability of remaining in service state 1 in time period t+1 is 0.1300, and the probability of still being in service state 1 in time period t+2 is (0.1300)(0.1300) = 0.0169. The probability of progressing to service state 2 in time period t+1 is 0.8120. The probability of attaining service state 2 in time period t+2 is the sum of two conditional probabilities: (a) the probability of attaining service state 2 given the individual was in service state 1 in time period t+1, (0.1300)(0.8120) = 0.1056; and (b) the probability of remaining in service state 2 in time period t+2 given the individual was in service state 2 in time period t+1, (0.8120)(0.3770) = 0.3061. The sum of these two conditional probabilities equals 0.4117, the value exhibited in Table B-1.

Of course, the combination of possible service states one could attain over 4 additional years of service increases each year by 2^n. For example, there are four possible combinations of positions which an individual beginning in service state 1 can attain over the next two time periods as illustrated in Figure B-1, $(2)^2 = 4$. These combinations of positions are: (P_{11},P_{21}), (P_{11},P_{22}), (P_{12},P_{22}), and (P_{12},P_{23}). To calculate the value to be accrued from 4 additional years of service, the probability of attaining each combination must be calculated for each year and then multiplied by the value of the service state which was attained in each additional year, discounted to time period t, and summed across all possible combinations of service states. Mathematically, this can be expressed as:

$$\text{SRVM Value} = \sum_{t=1}^{n} \left[\frac{\sum_{i=1}^{m} (V_i \bullet P_t(V_i))}{(1+r)^t} \right]$$

where t is the time period, i is the service state, V_i is the value of service state i, $P_t(V_i)$ is the probability of occupying service state i in time period t, r is the discount rate, n is the expected tenure, and m is the total number of service states (including exit). The discount rate used in the calculation of the SRVM values was the Treasury bill rate for calendar year 1986, 5.96%, though any other rate such as the prime lending rate would be equally acceptable. The smaller (larger) the discount rate used in the calculation, the larger (smaller) the SRVM value becomes.

The probability of occupying a service state in some future time period t is the sum of the probabilities of all the possible progressions to attain a particular service state in time period t+k, as demonstrated by Figure B-1. For example, the probability of attaining service state 2 in time period 2 depends on the sum of two probabilities. The first probability is the product of the probability of progressing from service state 1 to service state 2 in time period t+1 and the probability of remaining in service state 2 in time period t+2, (0.8120)(0.3770) = 0.3061. The second probability is the product of the probability of remaining in service state 1 in time period t+1 and

Table B-1. Transition Rates for 4-Year Tenure

		Time Period t+1							
	Service State	1	2	3	4	5	6	7	Exit
	1	0.1300	0.8120	0.0000	0.0000	0.0000	0.0000	0.0000	0.0580
	2	0.0000	0.3770	0.4820	0.0000	0.0000	0.0000	0.0000	0.1410
Time	3	0.0000	0.0000	0.6020	0.1750	0.0000	0.0000	0.0000	0.2240
Period	4	0.0000	0.0000	0.0000	0.8390	0.1190	0.0000	0.0000	0.0430
t	5	0.0000	0.0000	0.0000	0.0000	0.7980	0.1560	0.0000	0.0460
	6	0.0000	0.0000	0.0000	0.0000	0.0000	0.8140	0.0690	0.1170
	7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.8450	0.1550
	Exit	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

		Time Period t+2							
	Service State	1	2	3	4	5	6	7	Exit
	1	0.0169	0.4117	0.3914	0.0000	0.0000	0.0000	0.0000	0.1800
	2	0.0000	0.1421	0.4719	0.0844	0.0000	0.0000	0.0000	0.3021
Time	3	0.0000	0.0000	0.3624	0.2522	0.0208	0.0000	0.0000	0.3664
Period	4	0.0000	0.0000	0.0000	0.7039	0.1948	0.0186	0.0000	0.0846
t+1	5	0.0000	0.0000	0.0000	0.0000	0.6368	0.2515	0.0108	0.1010
	6	0.0000	0.0000	0.0000	0.0000	0.0000	0.6626	0.1145	0.2229
	7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7140	0.2860
	Exit	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

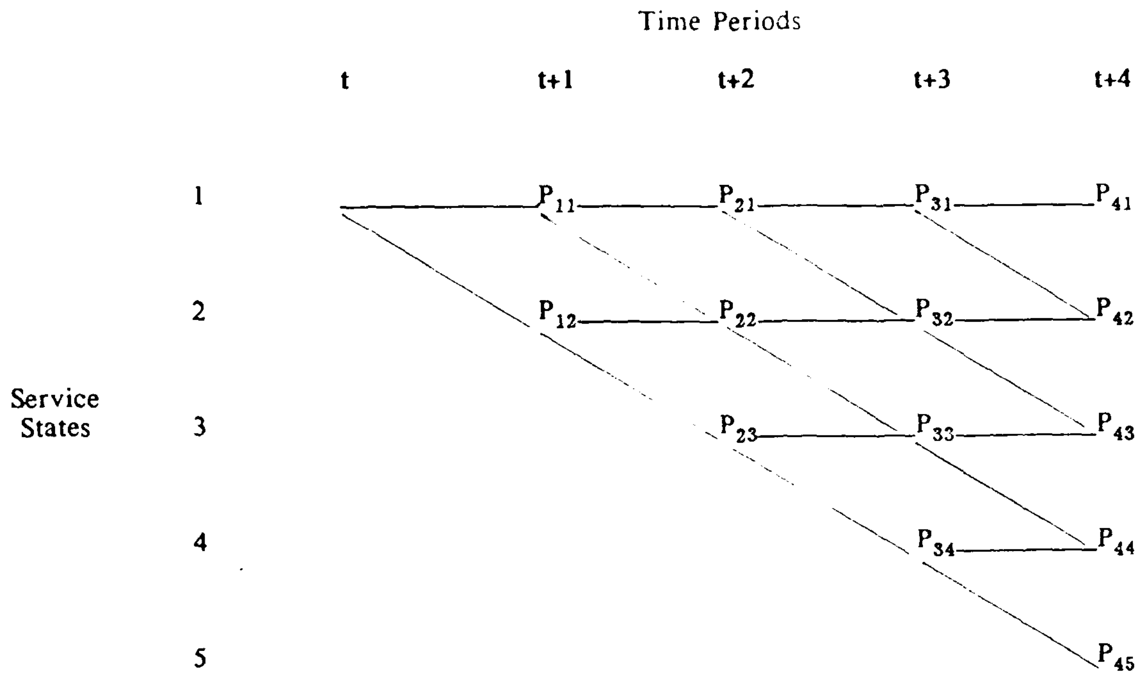
Table B-1 (Concluded)

Time Period t+3

	Service State	1	2	3	4	5	6	7	Exit
	1	0.0022	0.1689	0.4340	0.0685	0.0000	0.0000	0.0000	0.3267
	2	0.0000	0.0536	0.3526	0.1533	0.0100	0.0000	0.0000	0.4315
Time	3	0.0000	0.0000	0.2182	0.2750	0.0466	0.0032	0.0000	0.4594
Period	4	0.0000	0.0000	0.0000	0.5906	0.2392	0.0455	0.0013	0.1260
t+2	5	0.0000	0.0000	0.0000	0.0000	0.5082	0.3040	0.0264	0.1613
	6	0.0000	0.0000	0.0000	0.0000	0.0000	0.5394	0.1424	0.3182
	7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6034	0.3966
	Exit	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

Time Period t+4

	Service State	1	2	3	4	5	6	7	Exit
	1	0.0003	0.0655	0.3427	0.1334	0.0082	0.0000	0.0000	0.4508
	2	0.0000	0.0202	0.2381	0.1904	0.0263	0.0016	0.0000	0.5251
Time	3	0.0000	0.0000	0.1313	0.2689	0.0699	0.0099	0.0002	0.5226
Period	4	0.0000	0.0000	0.0000	0.4955	0.2612	0.0744	0.0042	0.1679
t+3	5	0.0000	0.0000	0.0000	0.0000	0.4055	0.3268	0.0433	0.2244
	6	0.0000	0.0000	0.0000	0.0000	0.0000	0.4390	0.1576	0.4034
	7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5098	0.4902
	Exit	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000



[a]P_{ti} is the probability of transitioning to service state i in time period t.

Figure B-1. Transition Probability[a] Through Time: Service State 1.

the probability of progressing to service state 2 in time period t+2, (0.1300)(0.8120) = 0.1056. Thus, the probability of attaining service state 2 in time period 2 is 0.3061 plus 0.1056, which equals 0.4117, as shown in Table B-1.

The expected value to be derived by the Air Force from an individual attaining service state 2 in time period 2 is the product of the probability of attaining service state 2 and the value of the service state, (0.4117)($16,952) = $6,979, *discounted* by the discount rate, $\$6,979/((1.0596)^2)$ = $6,216. Since an individual can attain service states 1, 2, 3, and 4 over a 4-year tenure, the expected value for each service state for each year must be calculated, discounted, and summed to attain the figure exhibited in Table 11 for service state 1, $47,132. Table B-2 provides a step-by-step calculation for service state 1 for a 4-year tenure.

The difference between SRVM and ENPVM is in the values assigned to the service states. The values assigned to the service states represent the value to be derived from an individual occupying the service state minus any costs associated with training, compensation, or bonuses. Table B-3 provides a step-by-step example of the calculation of the ENPVM for a 4-year tenure for service state 1. The estimated ENPVM value coincides with the amount provided in Table 15.

Table B-2. Calculation of SRVM for 426x2 for a 4-Year Tenure

Year	Expected Value	Discounted Value
1	(P_{11}) ($16,366) = $ 2,127.58	
	(P_{12}) ($16,952) = 13,765.02	
	15,892.60	$15,892.60/(1.0596) = $14,998.68
2	(P_{21}) ($16,366) = $ 276.59	
	(P_{22}) ($16,952) = 6,979.14	
	(P_{23}) ($18,839) = 7,373.58	
	14,629.31	$14,629.31/((1.0596)^2) = $13,029.86
3	(P_{31}) ($16,366) = $ 36.01	
	(P_{32}) ($16,952) = 2,863.19	
	(P_{33}) ($18,839) = 8,176.13	
	(P_{34}) ($22,143) = 1,516.79	
	12,592.12	$12,592.12/((1.0596)^3) = $10,584.56
4	(P_{41}) ($16,366) = $ 4.91	
	(P_{42}) ($16,952) = 1,110.36	
	(P_{43}) ($18,839) = 6,456.13	
	(P_{44}) ($22,143) = 2,953.88	
	(P_{45}) ($26,034) = 213.48	
	10,738.76	$10,738.76/((1.0596)^4) = $8,518.96

All 4 Years

($14,998.68 + $13,029.86 + $10,584.65 + $8,518.96) = $47,132.15

Note P_{ti} is equal to the probability of attaining service state i in time period t.

Table B-3. Calculation of ENPVM for 426x2 for a 4-Year Tenure

Year	Expected Net Value	Discounted Value
1	(P_{11}) (-\$15,370) = \$ -1,998.10	
	(P_{12}) (\$1,475) = 1,197.70	
	-800.40	\$-800.40/(1.0596) = \$-755.38
2	(P_{21}) (-\$15,370) = \$ -259.75	
	(P_{22}) (\$1,475) = 607.26	
	(P_{23}) (\$2,645) = 1,035.26	
	1,382.77	\$1,382.77/((1.0596)^2) = \$1,231.59
3	(P_{31}) (-\$15,370) = \$ -33.81	
	(P_{32}) (\$1,475) = 249.13	
	(P_{33}) (\$2,645) = 1,147.93	
	(P_{34}) (\$984) = 67.40	
	1,430.65	\$1,430.65/((1.0596)^3) = \$1,202.56
4	(P_{41}) (-\$15,370) = \$ -4.61	
	(P_{42}) (\$1,475) = 96.61	
	(P_{43}) (\$2,645) = 906.44	
	(P_{44}) (\$984) = 131.27	
	(P_{45}) (\$2,443) = 20.03	
	1,149.74	\$1,149.74/((1.0596)^4) = \$912.08

All 4 Years

(-\$755.38 + \$1,231.59 + \$1,202.56 + \$912.08) = \$2,590.94

Note P_{ti} is equal to the probability of attaining service state i in time period t.

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